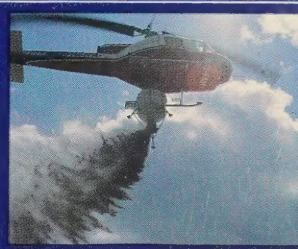
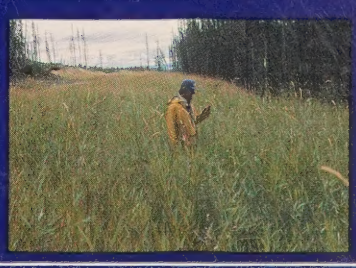
Canada

Reclamation Guidelines for Northern Canada





Reclamation Guidelines for Northern Canada

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for:
Land Resources, Northern Affairs Program

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

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dans le Nord Canadien.

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Preface

Resource exploration and development in northern Canada involves a range of land use activities, including the construction and maintenance of access roads, the clearing and preparation of hydrocarbon well sites, and the opening of borrow pits and rock quarries. To help the operators of small-to-medium scale projects carry out their activities in an environmentally acceptable manner, Indian and Northern Affairs Canada (INAC) has prepared a series of handbooks keyed to the operating conditions attached to Land Use Permits. To date, four handbooks have been published: "Environmental Guidelines Pits and Quarries", "Land Use Guidelines Mineral Exploration", "Land Use Guidelines Access Roads and Trails", and "Environmental Operating Guidelines: Hydrocarbon Well-sites in Northern Canada". By following the guidelines in these handbooks, the construction and operations phases of most projects can be carried out with minimal environmental impact.

This handbook, the fifth in the series, is designed to assist operators in reclaiming lands disturbed during project construction. It incorporates information gained from reclamation in northern Canada since 1970. This information was updated for INAC by Hardy BBT Limited during a 1984 field program which examined and assessed reclamation success at approximately one hundred sites in Northwest Territories and Yukon.

The study team received valuable assistance and guidance from the Steering Committee composed of Chris Cuddy, Sue Cramp, Ed Hornby, and Marg Crombie from Land Resources,Northern Affairs Program, Indian and Northern Affairs Canada.

The handbook was prepared by Hardy BBT Limited, Calgary, Alberta. Technical sections were written by W. E. Younkin, H. E. Martens, and A. J. Hanna. The handbook was compiled and edited by J. D. Howell.

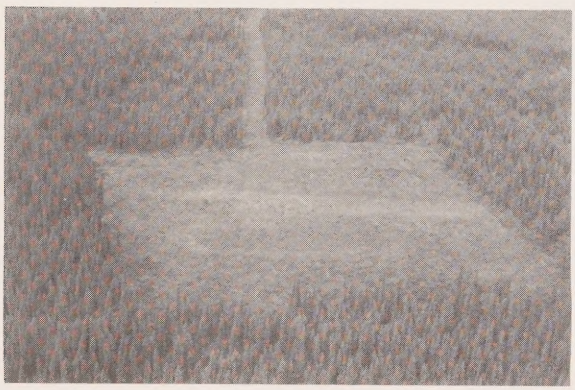
GUIDELINES PRESENTED HEREIN ARE SUBORDINATE TO ALL ACTS, ORDINANCES, AND REGULATIONS.

Chapter 1
Introduction

PURPOSE OF THE HANDBOOK

This handbook is written to assist contractors and operators of small-to-medium scale projects address Land Use Permit and Lease Conditions which deal with erosion control and land restoration. It is also written to assist Resource Management Officers in advising contractors and operators and inspecting land use sites. This handbook is meant to complement the other handbooks in the series and should be used in conjunction with the appropriate one for a given project.

The procedures contained herein deal with northern Canada where, because of the permafrost and short growing season, reclamation techniques can differ from those used in southern Canada. The handbook addresses reclamation situations where relatively simple reclamation techniques can be used. It does not apply to the reclamation of areas such as drilling mud sumps and mine tailings ponds where complex soil chemistry problems may require assessment by technical specialists.



• **properly reclaimed construction camp site**

WHAT IS RECLAMATION

Reclamation is any process which promotes soil conservation and returns land to a productive state. Generally, physical and biological methods are employed in achieving reclamation goals. The physical methods are directed at maintaining the stability of the soil surface and may consist of surface contouring, and drainage and erosion control structures. The biological methods are directed at re-establishing a vegetative cover to help stabilize the soil. The term "restoration" as used in the INAC Land Use Operating Conditions implies reclamation as defined here.

• **seeding as part of borrow pit reclamation**

WHY RECLAIM?

There are several reasons for reclaiming disturbed sites.

(1) Reduction of soil erosion — Soil is a valuable resource and where it is lost, reclamation will be more difficult and costly.

(2) Facility integrity — Reclamation can assist in protecting structures such as roads, pipelines, and earthworks by maintaining surface stability.

(3) Disturbance minimization — Reclamation can confine disturbances to the project area and protect downstream and downslope areas from the effects of erosion and sedimentation.

• **without reclamation, borrow pit sides are eroded**

(4) Maintenance savings — If the project area is stabilized as part of reclamation, the need to return to the site for maintenance is minimized. This may be particularly important in isolated areas where it may be expensive to move maintenance equipment to the site.

(5) Habitat recovery assistance — Reclamation can promote the recovery of natural habitat by stabilizing the surface and protecting the soil so that invasion by natural vegetation can occur.

(6) Aesthetics — Reclamation can be used to improve the appearance of disturbed areas, especially those areas visible from public roads.

• **a revegetated overburden dump**

HANDBOOK ORGANIZATION

Chapter 2 discusses reclamation in the context of the northern environment, identifying factors affecting reclamation success and modifications of reclamation procedures to achieve optimum results.

Chapters 3 through 7 address reclamation in northern Canada sequentially from the planning stage (Chapter 3) through the construction of drainage and erosion control measures (Chapter 4) and revegetation procedures (Chapter 5), to seeding recommendations (Chapter 6) and monitoring activities (Chapter 7). A worksheet for use during planning is included at the end of Chapter 3.

The final portion of the handbook presents a list of recommended references, a slope table, a seed mix and fertilizer conversion table, a list of INAC offices, and a glossary of reclamation terms.

• **this coal tailings pile, visible from a major road, has been reclaimed for aesthetic reasons**

Chapter 2
Northern Environment

The land north of 60° includes a wide range of vegetation, terrain, and climatic conditions. As one moves northwards, coniferous forest gradually gives way to open woodland, tundra, and polar desert in response to increasingly cooler and drier conditions. Much of the land is flat to gently rolling, yet large portions are covered by mountain ranges that extend arctic tundra conditions southwards into the forest region. Permafrost, which underlies much of the land is continuous and close to the surface in the north and discontinuous and at greater depths in the south.

RECLAMATION IN THE NORTH

Although many of the principles of reclamation applicable to southern areas can be applied in the North, they must be modified in response to two northern characteristics: permafrost and a short, cool growing season. The first influences terrain stability and drainage and erosion control measures while the second has a significant affect on revegetation efforts.

- **reclamation would have prevented this slumping**

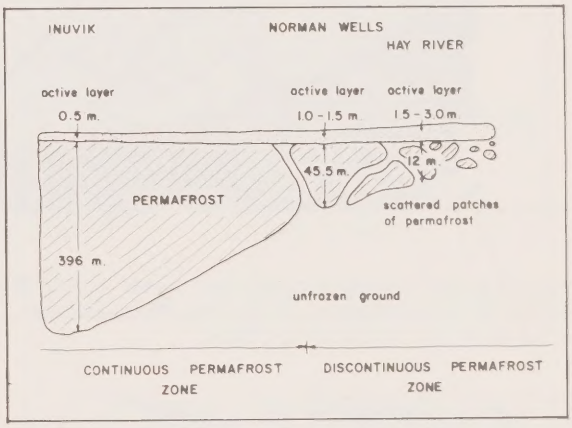
Growing Season

The growing season in the north is generally confined to the months of June, July, and August. It is during these relatively short, cool summers punctuated by frequent frosts that most of the vegetative growth occurs and revegetation success is determined. As a result of the cooler climate and short growing season, soils are poorly developed and generally low in plant nutrients.

Seeded species must be able to germinate and establish quickly during the short growing season – those that can not will not survive the harsh northern winter. Most species adapted to southern regions are not able to establish and survive in this environment. The number of northern revegetation species commercially available decreases toward the north until, in the Polar Desert, there are no known commercial species suitable for revegetation.

Permafrost

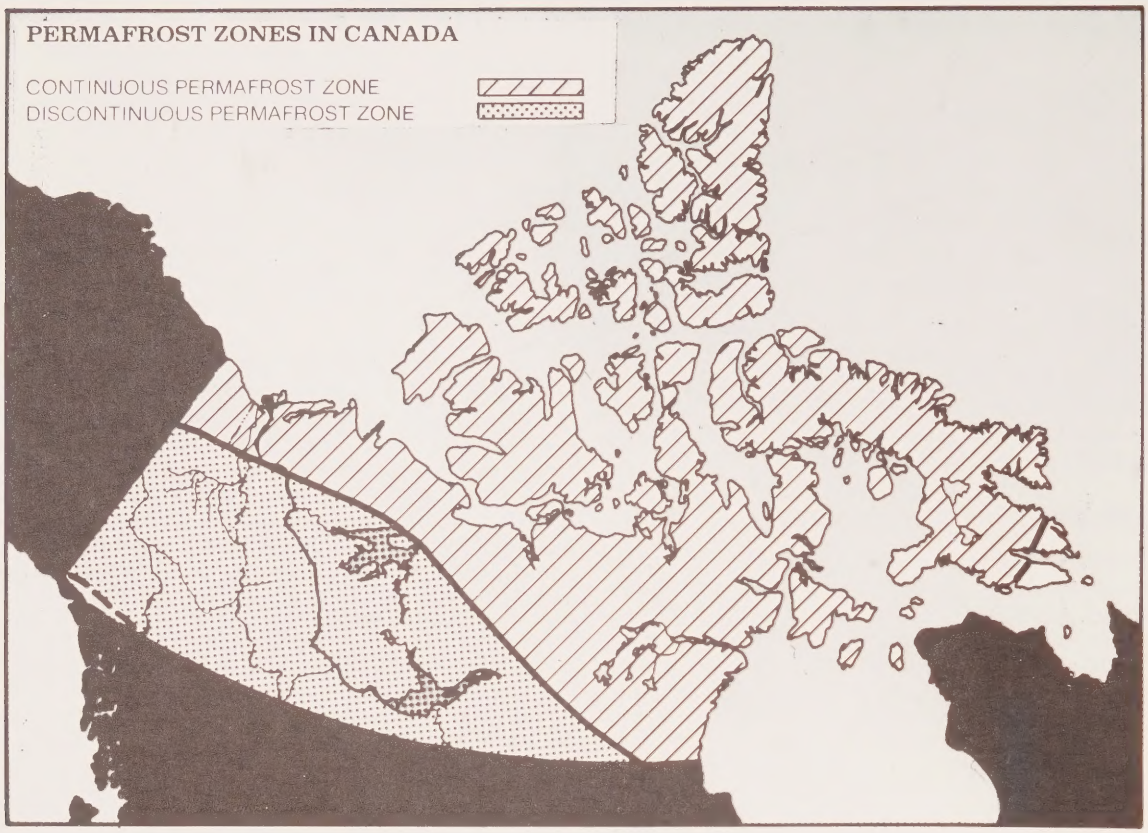
Permafrost is ground that remains frozen through at least two consecutive winters and the intervening summer. It can consist of mineral soil, organic soil, or rock, and can be either ice-free or ice-rich. Permafrost varies in thickness from a few centimetres near the southern limits of its range to several hundred metres in the north. An annually thawed zone, called the active layer, overlies the permafrost. This active layer varies in thickness from 20 to 60 cm in the north to several metres in the south.



- continuous and discontinuous permafrost
- active layer

Permafrost is found across northern Canada. Its distribution is divided into two zones: the continuous zone and the discontinuous zone. In the continuous zone, permafrost is present under all land surfaces; active layers are thin and permafrost is thick. In the discontinuous zone, permafrost is found under certain conditions only. In the northern portions of this zone, the permafrost is widespread; in the southern portions it is scattered. Discontinuous permafrost also occurs in the Cordillera, south of the permafrost limit. The typical locations of permafrost in the discontinuous zone are on north-facing slopes, within muskeg, and on shaded terrain with minimal snow cover.

Permafrost often impedes internal drainage and, with the exception of slopes, soils are saturated during much of the growing season. Natural drainageways are often subtle and ill defined, yet boggy ground developed over



permafrost can release erosive flows of water during much of the growing season. These factors make drainage and erosion control planning difficult.

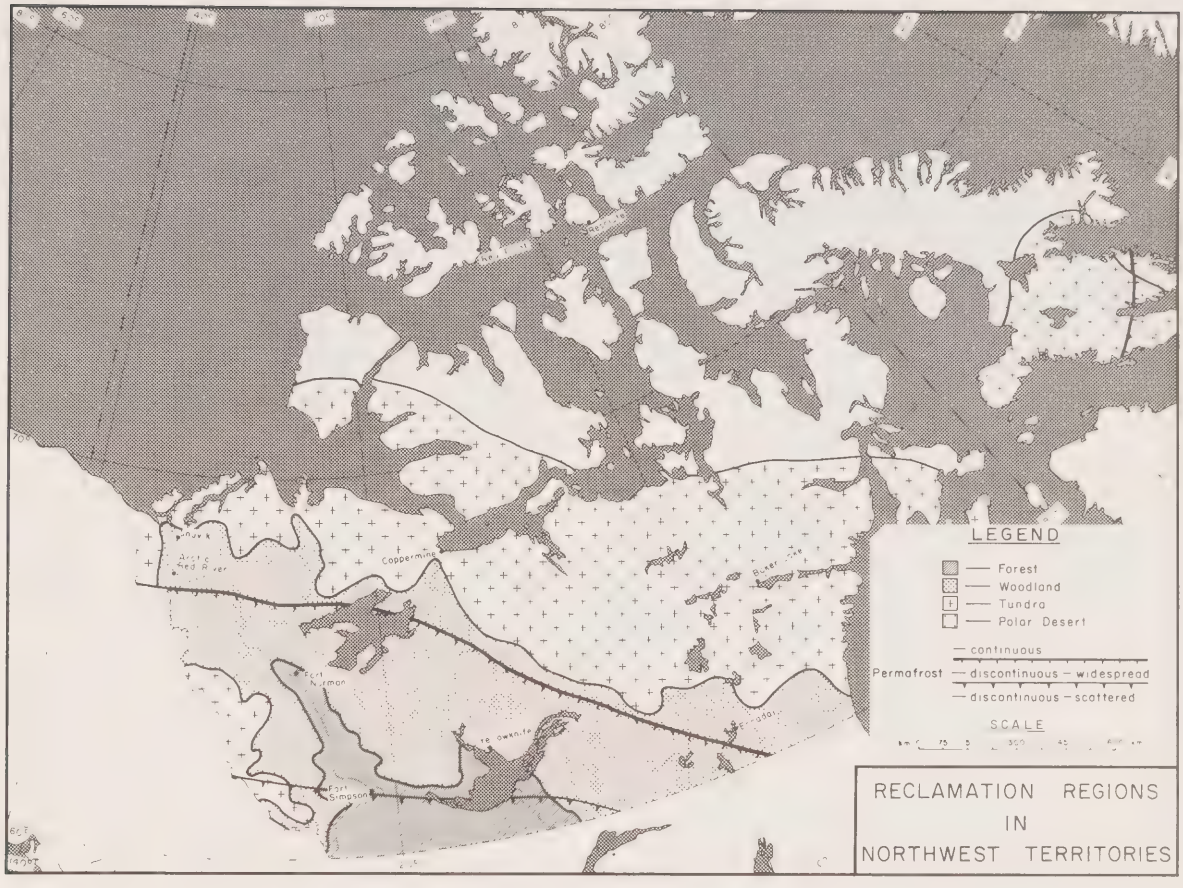
- **thaw-sensitive permafrost will slump and flow when disturbed**

The organic mat insulates permafrost, protecting it from thawing. Any activity which disturbs this mat may result in thawing and slumping of the surface which, in severe cases, may render drainage and erosion control measures useless. The extent of thawing and slumping will depend on whether the permafrost is thaw unstable or thaw stable. Thaw-unstable permafrost loses its strength when thawed due to the melting of excess ice in the soil. Thaw-stable permafrost contains little or no ice and when the permafrost thaws, slumping is minimal to non-existent. As a rule-of-thumb, if lenses, layers, veins, or masses of ice are visible in a soil, it is thaw-unstable.

RECLAMATION REGIONS

Four northern reclamation regions can be identified on the basis of a general uniformity in climate and natural vegetation: Polar Desert, Tundra, Woodland, and Forest. The distinctions between the regions are not always clear cut and pockets of one region may occur within another. Determine which region your project area is in through discussions with your Land Use Inspector.

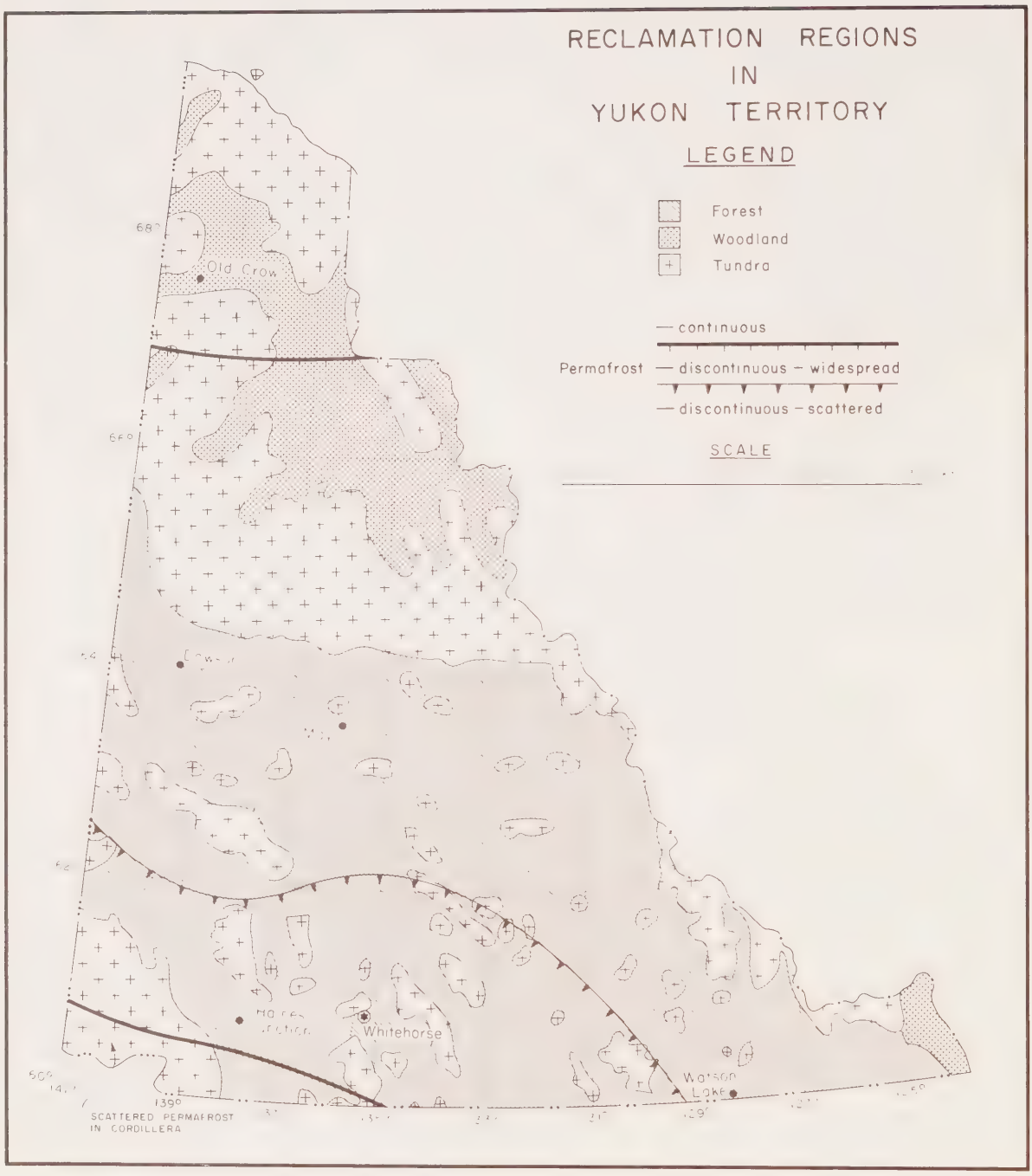
Each of the regions has somewhat different limitations to reclamation and reclamation practices have to be modified accordingly.



Polar Desert

The Polar Desert encompasses most of the arctic islands. The vegetation cover is generally incomplete and ranges from a sparse covering of lichens and low-growing cushion plants, in better drained areas, to sedges and grasses in wetter sites. The growing season is extremely short and cool, with only 30 frost-free days each year and monthly temperatures during this period averaging 0° to 4°C. Although growing season precipitation averages less than 50 mm, soils are generally saturated due to the presence of permafrost within 50 cm of the surface. Unlike areas further to the south, the organic mat, where present, plays only a minor role in insulating permafrost and its disturbance or removal does not generally result in severe thawing or slumping. Because of the severe environment, no revegetation species have been identified for this region, limiting reclamation practices to drainage and erosion control.

• **typical Polar Desert landscape**


RECLAMATION REGIONS
IN
YUKON TERRITORY
LEGEND
Forest
Woodland
Tundra
Permafrost
— continuous
— discontinuous – widespread
— discontinuous – scattered
SCALE
Old Crow
Whitehorse
Watson Lake
68°
66°
62°
60°
141°
139°
129°
SCATTERED PERMAFROST
IN CORDILLERA

• **revegetation practices have little success in the Polar Desert**

• **typical Tundra landscape**

Tundra

The Tundra extends north from the tree line to the arctic coast and includes some of the southern portions of the arctic islands. Areas above treeline in mountain ranges are also included in this region. The vegetation cover is nearly complete and includes dwarf shrubs, heaths, sedges, grasses, mosses, and lichens. Better-drained areas are typified by dwarf birch and willow shrubs grading to cottongrass tussocks and wet sedge meadows. The growing season is short and cool with mean monthly temperatures ranging from 3° to 9°C. The frost-free period averages 83 days. Growing-season precipitation averages less than 100 mm. Permafrost, however, is generally less than 1 m from the surface, impeding internal drainage and keeping all but those soils on steep slopes moist-to-wet.

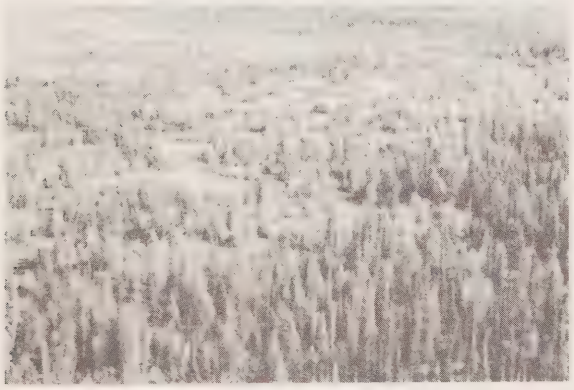
As in the Polar Desert, permafrost is continuous and in many areas is ice rich. The organic mat and vegetation cover are important in protecting the permafrost from thawing and when they are disturbed subsidence and slumping can result. Because of this, the installation of drainage and erosion control measures in ice-rich permafrost must be done with a minimum of surface disturbance. Natural vegetation recovery following disturbance is slow in this region, however assisted revegetation is possible using appropriate species and seed mixes.

RECLAMATION REGION	CHARACTERISTIC VEGETATION	PERMAFROST CHARACTERISTICS	RECLAMATION CONSIDERATIONS
Polar Desert	Better-drained sites support lichens and low-growing cushion plants. Wetter sites support sedges and grasses. Vegetation cover is incomplete.	Permafrost is continuous. Active layers are 20-60 cm. The organic mat plays only a minor role in insulating the surface.	Disturbance to the organic mat during the installation of drainage and erosion control measures is not a problem. No revegetation species identified.
Tundra	Better-drained sites support dwarf birch and willow shrubs. Wetter sites support cottongrass tussocks and wet sedge meadows. Vegetation cover is nearly complete.	Permafrost is continuous. Active layers are 40-100 cm. The organic mat and vegetation cover are important in insulating the surface.	Installation of drainage and erosion control measures in ice-rich permafrost must be done with a minimum of disturbance to the organic mat. Natural vegetation recovery is slow; assisted revegetation is possible.
Woodland	Better-drained sites support open park-like stands of black spruce, white spruce, and tamarack with alder and willow shrubs. Wetter sites support extensive areas of black spruce bogs and sedge-dwarf birch fens. Vegetation ground cover often consists of light-coloured lichens alternating with patches of grassy or shrubby vegetation or with rocky barrens.	Permafrost is continuous in the northern part of the region only; and is discontinuous throughout the rest of the region. Active layers are 80-200 cm. The organic mat and vegetation cover are important in insulating the surface.	Unprotected areas, even on gentle slopes, can be subject to severe erosion during spring breakup. Great care need be taken in the design and placement of drainage and erosion control devices because of the variable ice content of the permafrost. A number of commercial revegetation species have been identified for the area.
Forest	Major tree species include white and black spruce, jack pine, tamarack, white birch, aspen, and balsam poplar. Most the region is covered by forest, although there are large areas of bog and fen on water sites.	Permafrost is discontinuous. Active layers are 100-200 cm, in general, but shallower in poorly-drained organic soils.	Unprotected areas, even on gentle slopes, can be subject to severe erosion during spring breakup. Great care need be taken in the design and placement of drainage and erosion control devices because of the variable ice content of the permafrost. A number of commercial revegetation species have been identified for the area.

Woodland

The Woodland region covers an extensive area south of the treeline. It is composed of muskeg intermixed with open stands of dwarfed trees and local patches of denser, taller trees in protected sites. Better-drained areas support open park-like stands of black spruce, white spruce, and tamarack with alder and willow shrubs. Wetter areas support extensive black spruce bogs and sedge-dwarf birch fens. Although generally found on level terrain, woodlands also occupy the slopes of the mountains along the Yukon — Northwest Territories boundary and the Ogilvie Mountains — Eagle Plains in northern Yukon. The growing season is cool, with mean monthly temperatures averaging between 10° and 14°C. Permafrost is continuous only in the northern part of the region. Active layers range from 80 to 200 cm. A blanket of peat covers much of the surface except on slopes where shallow active layers and solifluction largely prevent its development. As in the Tundra region, the permafrost is protected by the organic layer and is subject to thawing and slumping where the layer is disturbed.

Although much of this region is relatively flat and featureless, careful planning for drainage and erosion control is necessary. Large volumes of water move across the region during spring breakup and unprotected mineral soils, even on gently sloping terrain, can be subject to severe erosion. A number of revegetation species have been identified to provide both short- and long-term protection for mineral soils in the region. Organic soils, located on stable, flat-to-depressional terrain, are not as susceptible to erosion and assisted revegetation is generally not given a high priority.



• **typical Woodland landscape**

Forest

The Forest region lies predominantly to the south of the Woodland except in the Mackenzie River Valley and around Great Slave Lake where it extends northwards due to the moderating effects of the waterbodies. Most of the region is covered by forest although there are large areas of bog and fen, particularly in the vicinity of Fort Simpson. Major forest species include spruce, pine, birch, aspen, and poplar. This region has the most moderate growing season conditions in the North, with mean monthly temperatures ranging from 13° to 15°C and monthly precipitation ranging from 40 to 50 mm. Sawlog-sized timber is not uncommon on the medium-textured soils of flood plains along the larger rivers (Mackenzie, Liard, Arctic Red, etc.).

Permafrost is discontinuous in this region and active layers are often greater than 2 m. On better-drained sites, especially in the south, soils are free of permafrost and relatively thick. On poorly-drained sites, organic soils have developed and permafrost is often present near the surface. Except for the occurrence of permafrost, the reclamation potential of this region is similar to boreal forest regions in the rest of Canada. However, because slight changes in slope, aspect, and drainage can greatly affect the presence and ice content of permafrost, care needs to be taken in the design and placement of drainage and erosion control devices. Here, as in the Woodland, drainage patterns can be subtle and spring run-off intense. Areas of even minor relief can be subject to erosion which will be compounded by the presence of permafrost. Because of the milder climate, soils are much better developed than in the other reclamation regions and are often suitable for salvage. A large number of species are available for revegetation, many of which can provide a relatively high level of first year cover.

• **typical Forest landscape**

Chapter 3
Planning

Reclamation should be considered throughout a project's life, not only in the final stages. The development of a reclamation plan prior to construction will not only minimize the impact of the project but will increase the cost efficiency of final reclamation.

PLANNING, PRIOR TO CONSTRUCTION, MINIMIZES RECLAMATION EFFORTS LATER.

Guidelines on developing a reclamation plan will be presented in this chapter. A worksheet to use when developing a reclamation plan appears at the end of the chapter.

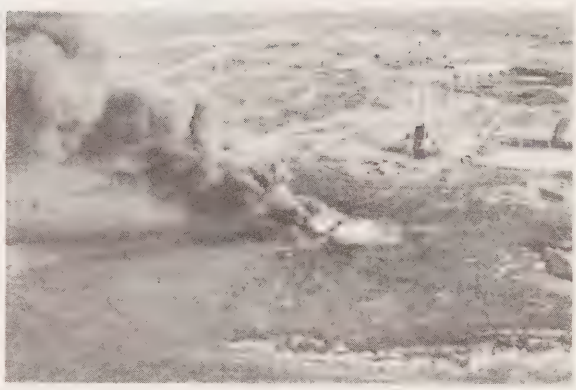
DETERMINING BROAD RECLAMATION REQUIREMENTS

Reclamation requirements will depend upon the purpose of the reclamation and the reclamation region in which the project is located. The following questions will assist in determining the purpose and level of reclamation activity required.

IS SURFACE EROSION ANTICIPATED TO BE A PROBLEM? IS THE SITE BEING RECLAIMED TO ENSURE TERRAIN STABILITY?

In areas where clearing and construction will result in bare slopes of easily erodible material or where permafrost will be exposed to thawing, specific reclamation plans will be required to maintain terrain stability and prevent erosion. If, however, the project occurs in a region where the potential for erosion is negligible and the area is expected to revegetate naturally, reclamation may not be necessary. If you think your project falls in this category, discuss it with your Land Use Inspector.

- **fisheries habitat will be damaged if this right-of-way is not reclaimed**



- **site clean up was sufficient to restore this well site in the Polar Desert (top photo) to a near-natural condition (bottom photo)**

IS THE ASSISTANCE OF HABITAT RECOVERY A MAJOR GOAL?

Projects occurring in or near good fish or wildlife habitat should be reclaimed such that comparable habitat is encouraged to establish. In these instances, emphasis will be placed on revegetation and both sloping and level terrain will require reclamation.

ARE AESTHETICS IMPORTANT?

In highly visible areas, the aesthetics of the disturbed land may be important. In these cases, contouring, drainage and erosion control, and revegetation may all receive equal emphasis.

• **a properly reclaimed right-of-way improves aesthetics**

DEVELOPMENT OF A RECLAMATION PLAN

Before developing the reclamation plan for your project, you should have decided what the desired post-reclamation landscape will be. This will have evolved from the earlier exercise of identifying the reclamation requirements. Early identification of the post-reclamation landscape will aid in the planning of certain construction activities, such as grading and spoil disposal, so that the amount of post-construction activity will be minimized.

The development of a reclamation plan consists of six steps:

(1) Identify the type, location, and extent of the surface disturbance.

(2) Determine surface conditions following disturbance.

(3) Determine soil handling procedures.

(4) Determine drainage and erosion control requirements.

(5) Determine revegetation requirements.

(6) Schedule reclamation and order materials.

Although it appears that a great deal of information is required, most will be available as part of the normal pre-construction planning for a project. Each step is explained below and the information to be collected is listed on the reclamation worksheet at the end of the chapter.

INFORMATION FOR RECLAMATION PLANNING IS COLLECTED AS PART OF GENERAL PROJECT PLANNING.

(1) Identify the Type, Location, and Extent of the Surface Disturbance

DETERMINE THE TYPES OF SURFACE DISTURBANCE EXPECTED

For the purposes of reclamation, surface disturbances resulting from project activities can be classified into two types:

(a) Those with minimal disruption of the soil surface

(b) Those with major disruption of the soil surface such as excavation or extensive grading

Most projects are likely to have both types present to some degree. The type of disturbance is one factor in evaluating drainage and erosion control requirements. It will also determine whether assisted revegetation is required or natural recovery is sufficient. Surfaces with minimal disruption may revegetate naturally while those with major disruptions such as excavation or grading, will likely require some type of revegetation assistance.

• **sites cleared with minimal surface disruption may revegetate on their own**

- **sites that are extensively graded will require revegetation assistance**

MINIMIZE RECLAMATION REQUIREMENTS THROUGH PROPER FACILITY SITING

The location of the disturbance plays an important role in determining reclamation requirements. To minimize reclamation efforts later, the following goals should be kept in mind during project planning and development:

(a) Confine surface disruption and excavation to level or gently sloping terrain.

(b) Avoid surface disruption and excavation in ice-rich permafrost and fine-grained, poorly-drained soils.

(c) Locate stream crossings at sites with gentle approaches and coarse-grained soils.

(d) Locate structures at camps and well sites as close together as site conditions, licences, and Land Use Terms and Conditions allow.

MINIMIZE THE EXTENT OF THE AREA DISTURBED

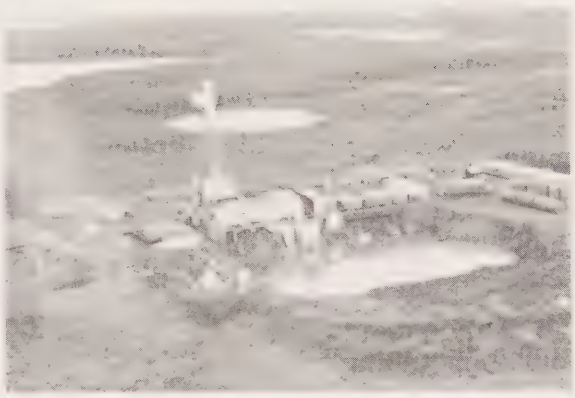
The size of the disturbed area partially determines the reclamation requirements and the cost of reclamation. To minimize the disturbance:

(a) Restrict clearing to the minimum area needed for development.

(b) Plainly mark the area to be cleared.

(c) Confine construction activities to the cleared area.

INDICATE THE AREA TO BE DISTURBED AND THE TYPE OF DISTURBANCE ON MAPS AND PHOTOS OF THE PROJECT AREA.



- **locate facilities as close together as site conditions, licences, and Land Use Terms and Conditions allow**

(2) Determine Surface Conditions Following Disturbance

Following disturbance, five components of surface conditions will play a major role in determining reclamation requirements:

(a) Degree of slope

(b) Type of soil

(c) Soil texture

(d) Soil moisture status

(e) Presence or absence of permafrost

GRADES GREATER THAN 5 PERCENT MAY REQUIRE EROSION CONTROL

Disturbed surfaces on grades greater than 5 percent* may require erosion control measures to ensure surface stability while a plant cover is established (Chapter 4).

ORGANIC SOILS MAY NOT REQUIRE EROSION CONTROL MEASURES; MINERAL SOILS PROBABLY WILL

Organic soils generally develop on level terrain and have a low erodibility. If disruption of the surface is minimal, erosion control measures may not be required and natural revegetation may be adequate. If, however, the organic soil has been pulverized or slurried and concentrated flows of water are anticipated, such as during spring breakup, erosion control measures will be necessary and assisted revegetation may also be required.

* Throughout the handbook, slopes are described in terms of percent grade. See Appendix A for a table comparing slope grades, angles, and ratios.

- **erosion control measures will be necessary for the slurried organic soil on the right of the photograph**

Mineral soils are generally more erodible than organic soils and will likely require erosion control measures and assisted revegetation.

GRAVELLY AND SANDY SOILS ARE LESS ERODIBLE THAN SILTY AND CLAYEY SOILS

Soil texture plays a role in soil erodibility and moisture holding capacity and, therefore, the type of reclamation measures required. Gravelly and sandy soils tend to be less erodible and have a lower soil-moisture storage capacity than silty and clayey soils. As a result, they will generally require less extensive erosion control measures but more extensive revegetation assistance than silty and clayey soils.

- **this mineral soil requires erosion control and revegetation**

DETERMINE SOIL MOISTURE STATUS

Seed mixtures within a given reclamation region should be selected on the basis of the soil moisture status of the surface to be revegetated (Chapter 6). Two broad ranges of soil moisture are used in making seed selection: dry-to-moist and moist-to-wet (including soils flooded in spring).

DESCRIBE PERMAFROST CHARACTERISTICS

Permafrost characteristics (Chapter 4) will affect the type and extent of drainage and erosion control measures required and will also partially determine the soil moisture status.

INDICATE SURFACE CONDITIONS ON MAPS AND PHOTOS OF THE DEVELOPMENT AREA

(3) Determine Soil Handling Procedures

STRIP AND STORE SOIL FOR USE IN RECLAMATION

In almost all cases the surface soil is the best material for revegetation and should be salvaged when excavation or deep grading is required. To efficiently salvage this material, the following should be determined:

(a) Where to strip

(b) How deep to strip

(c) Where to store the stripped soil

(d) Where to reapply the stripped soil

STRIP SOIL FROM AREAS REQUIRING EXCAVATION OR DEEP GRADING

Soil should be stripped from excavations such as borrow pits, sumps, and mines; and areas of extensive grading.

- **strip and save surface soil for re-application prior to revegetation**

STRIP THE TOP 15 TO 40 cm OF THE SOIL

The material that should be stripped is that portion of the soil with the majority of plant roots. This is usually the top 15 to 40 cm.

STORE THE STRIPPED SURFACE SOIL SEPARATELY FROM THE SUBSOIL

The stripped soil should be stored separately from excavated subsoil to prevent mixing. Storage sites are best located on dry, level ground and where they will not interfere with development or become contaminated.

INDICATE AREAS OF SURFACE SOIL STRIPPING, STORAGE, AND REAPPLICATION ON MAPS AND PHOTOS OF THE DEVELOPMENT AREA

(4) Determine Drainage and Erosion Control Requirements

Once the surface disturbance has been characterized, the surface conditions described, and the materials-handling procedures developed, drainage and erosion control requirements can be determined. These will have to be determined for any soil storage piles as well as the disturbed area itself. Drainage and erosion control is discussed in Chapter 4.

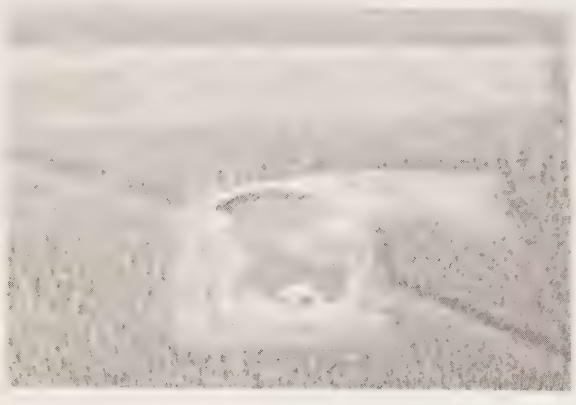
INDICATE DRAINAGE AND EROSION CONTROL FEATURES ON MAPS AND PHOTOS OF THE DEVELOPMENT AREA

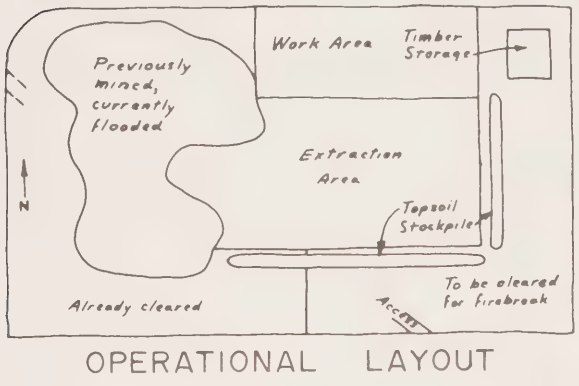
- **if this surface soil stockpile is to be left for more than one growing season, it should be revegetated**

(5) Determine Revegetation Requirements

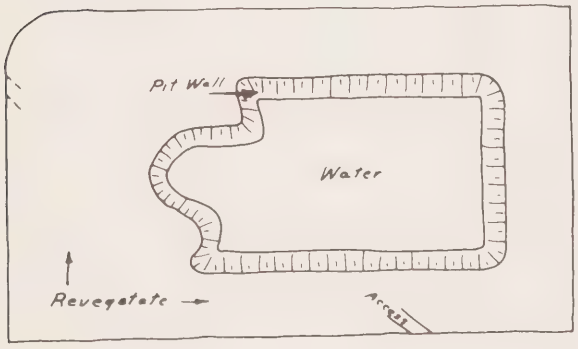
Following the determination of drainage and erosion control requirements, revegetation requirements should be determined. These are discussed in Chapters 5 and 6. Soil remaining in storage for more than one growing season may have to be revegetated to reduce soil losses through erosion.

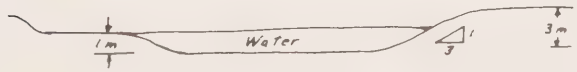
INDICATE REVEGETATION SPECIFICATIONS ON MAPS AND PHOTOS OF THE DEVELOPMENT AREA





OPERATIONAL LAYOUT





FINAL RECLAIMED LAYOUT

- **use photographs and maps to outline reclamation plans prior to commencing field activities**

(6) Schedule Reclamation and Order Materials

IMPROPER RECLAMATION SCHEDULING MAY BE COSTLY

Proper scheduling of reclamation activities is important. Where possible, reclamation should be carried out progressively with construction to make best use of the equipment on site and minimize the need (and expense) of bringing equipment back later.

Materials needed for reclamation should be ordered prior to the start of the construction phase so that they will be on site when needed. Bear in mind the cost of shipping the seed and fertilizer and schedule to take advantage of ground transportation to reduce costs.

- **order your reclamation materials early so they will be on site when needed**

Reclamation Worksheet

The structure of this worksheet follows that of the handbook, covering type of surface disturbance expected, surface conditions, erosion control, revegetation, and monitoring. Page numbers following each item in the worksheet refer to where further information on the topic is available in the handbook. By reading through the worksheet, considering the points presented, and filling in the blanks where applicable, reclamation measures for your project will be outlined.

DESCRIPTION OF EXPECTED DISTURBANCE

1. Will there be minimum disruption to the soil surface or will there be a major disruption such as excavation or extensive grading? (p. 11)

2. What are the slope angles in the disturbed areas? (p. 12) Where possible, confine surface disruption and excavation to gently sloping terrain.

3. Does the disturbance occur on organic soils or mineral soils? (p. 12) Soil type will affect soil moisture content and the potential for erosion.

4. Are surfaces expected to be wet? (p. 13) Wet sloping surfaces may require additional attention to control erosion.

5. Is permafrost present? If so, is it ice-poor, moderately ice-rich, or ice-rich? (p. 22) Avoid surface disruption and excavation in ice-rich permafrost as this material is erosion prone.

6. Determine the minimum area needed for development. (p. 12) Restrict construction activities to this defined area.

7. To assist in planning, sketch or photograph the area to be disturbed and indicate the extent and nature of the disturbance. (p. 15)

EROSION CONTROL

8. Determine the angle to which disturbed slopes will be graded. (p. 21)

_____

_____

9. Make vertical cuts in ice-rich permafrost. (p. 22)

10. Will excavations or ditches be backfilled with frozen soil? If yes, determine where these will be and make allowances for settlement. (p. 22)

11. Have allowances been made for cross flow on linear facilities? If yes, where and how? (p. 23)

12. Will diversion berms be required? If yes, where? (p. 23)

13. Will the berms be constructed of soil or will sand bags be used? (p. 24)

14. Regarding berms:
    (a) Space berms according to the Table on p. 24.
    (b) Ensure that the gradient along the berms is between 5 and 10 percent or that the berm itself is inclined at least 60° to the fall line. (p. 24)

15. Will drainage channels have to be re-routed? If yes, where and how? (p. 25)

16. How will drainage ditches be lined. (p. 25)

17. What will be used for ditch blocks? (p. 25)

18. Will erosion control blankets be necessary? If yes, where? (p. 26)

REVEGETATION

19. Will assistance from a reclamation specialist be required? (p. 33)

20. Can the surface be allowed to revegetate naturally? (p. 27)

21. Will the surface soil be stripped and saved for re-application? If yes, what areas will be stripped and to what depth? (p. 13)

22. Where will the stripped soil be stored? (p. 14)

23. What will be done to prepare the surface for revegetation? (p. 27)

24. Where will the saved surface soil be spread? (p. 28)

25. Indicate which surfaces will be ripped and scarified. (p. 28)

26. Determine seed specifications and purchase Canada No. 1 certified seed only. (p. 32)

27. Determine fertilizer requirements. What formula of fertilizer will be needed and what amount? (p. 33)

28. Determine the dates for which seeding can be successfully carried out at your site. (p. 28)

29. Select appropriate equipment and calibrate your seed/fertilizer spreader. (p. 29)

30. Where possible, harrow to cover the seed with soil. (p. 30)

31. Consider the use of willow cuttings where additional subsurface soil strength is needed. Identify the areas requiring cuttings and the source of cuttings. (p. 30)

MONITORING

32. What are the monitoring objectives? (p. 35)

33. Establish monitoring transects where appropriate. (p. 35)

NOTES AND SKETCHES

Chapter 4
Drainage and Erosion Control

Following planning, drainage and erosion control is the first step in reclaiming a site. The primary goal of this step is the immediate stabilization of the surface. A secondary goal is the establishment of a stable surface on which revegetation can occur. Commencing revegetation activities without first considering drainage and erosion control can result in decreased success or even failure of the revegetation efforts.

IMPLEMENT DRAINAGE AND EROSION CONTROL MEASURES TO STABILIZE THE SURFACE

- **this slope has failed because revegetation was carried out without first implementing drainage and erosion control measures**

Drainage and erosion control is carried out in two stages:

(1) Slope contouring

(2) Establishment of drainage and erosion control structures

SLOPE CONTOURING

Projects that involve earth movement will likely require some degree of grade restoration or side-slope contouring during reclamation. Grades should be consistent with the surrounding topography, must not impede surface runoff, and should be such that water is shed away from excavations and structures.

- **a properly contoured slope ready for seed application**

DIRECT RUNOFF AWAY FROM CUTS AND STRUCTURES

Side Slopes Without Permafrost

Side slopes without permafrost should be rounded at the top and toe to reduce the potential for slope failure.

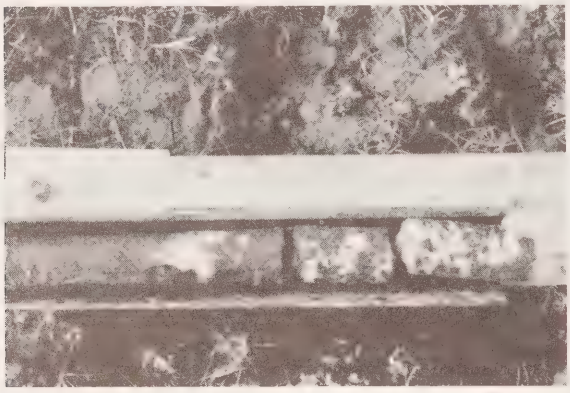
DO NOT CREATE A SMOOTH SURFACE

The surfaces should be compacted and graded to no steeper than a 50 percent grade if the side slope is composed of sand or gravel and is well drained, or a 33 percent grade if it is composed of fine-grained sediments and is poorly drained. Rocks, which help to create microsites for revegetation, should be left unless they are likely to roll down the slope.

- **erosion is not stopped by contouring alone — revegetation is also needed**

Side Slopes With Permafrost

When contouring side slopes with permafrost, consideration must be given to the presence of frozen soil. The behavior of frozen soil during thawing depends, to a large extent, on the amount of excess ice present. This excess ice commonly exists in thin layers or lenses. By visual examination, the amount of these pure ice layers within a frozen soil sample or on an exposed cut face can give an approximation of the excess ice, expressed as a percentage of the total thickness of ice to the total thickness of frozen sample.



- **total thickness of ice approximately 25 cm; total thickness of sample approximately 50 cm; excess ice = 25/50 = 50 percent**

ICE-RICH SIDE SLOPES REQUIRE SPECIAL CONSIDERATION

To decide how to contour side slopes between 1 and 5 m high in areas of permafrost, follow the guidelines below. For slopes greater than 5 m, consult a geotechnical engineer.

(1) If the side slope is ice poor (less than 5 percent visible excess ice), trim it to no steeper than a 50 percent grade and round the top and toe.

(2) If the side slope is moderately ice rich (5 to 20 percent visible excess ice), or expected to be wet due to runoff or active layer seepage, trim it to at least a 33 percent grade and round the top and toe.

(3) If the side slope is ice rich (more than 20 percent visible excess ice) make a vertical cut and leave the slope to stabilize naturally. Experience has shown that vertical cuts between 1 and 5 m high in ice-rich soil can stabilize although the process may take several years. Retain the organic mat behind the cut as it forms an important element in the stabilizing process. Trees on top of the cut must be removed for a distance equal to twice the height of the cut. Otherwise, as the cut stabilizes itself, the trees will fall, tearing the organic mat in the process. Do not leave ice-rich side slopes at 50 percent or gentler grades because long-term unstable conditions could develop.

the vertical cuts in this ice-rich slope (top photo) stabilized naturally in one year (bottom photo)

ALLOW FOR SETTLEMENT OF BACKFILL

Excavations and ditches backfilled with frozen soil will experience a certain amount of settlement upon thawing. Depressions resulting from this settlement can collect water and this is normally undesirable.

Where the spoil is not ice rich it may be sufficient to raise the backfill level above the surrounding grade to accommodate the thaw settlement. A good rule-of-thumb is to overfill by 20 percent.

If the spoil is ice-rich, it may be necessary to provide a more thaw-stable soil for backfilling, particularly on sloping ground where ice-rich spoil could flow upon thawing.

- **backfill with thaw-stable (ice-poor) soil**

ESTABLISHMENT OF DRAINAGE AND EROSION CONTROL STRUCTURES

Drainage control and erosion control go hand-in-hand in that if drainage is controlled, a major portion of erosion will be controlled as well.

Drainage and erosion control begin during the establishment of final grades by accommodating the original drainage pattern for the area and by ensuring adequate drainage over the disturbed site. Meeting these objectives may involve the construction of diversion berms and drainage ditches which direct water across or away from the disturbance and, where necessary, the emplacement of erosion control mats.

- **the opening in the berm allows cross flow on this right-of-way**

ALLOW FOR CROSS FLOW

On linear facilities allowance must be made for cross flow of surface drainage at all topographic low points and at regular intervals on sloped sections. Windrows of soil or clearing debris must be opened to allow cross flow.

In areas with permafrost, water should not be allowed to pond on or beside the right-of-way, nor should it be channelled along the side of the right-of-way. The water warms the permafrost, resulting in thawing and erosion.

Diversion Berms

When reclaiming sites with longitudinal grades greater than about 5 percent, diversion berms will be required to prevent the formation of gullies on the surface. The berms should extend randomly 1 to 3 m beyond the edge of the disturbance to prevent concentrated flow and to direct water onto undisturbed terrain.

- **diversion berms are needed to control erosion on slopes**

CONTROL ERODED SEDIMENTS

Some form of control structure will normally be required to reduce the flow velocity and trap any eroded soils at the end of diversion berms. Otherwise, the diverted runoff could erode the area beyond the reclaimed site. Boulders, timber logs, and slash can be effectively used for this purpose. These measures may not be required if the terrain and plant cover at the end of the berm remains undisturbed.

SPACE BERMS ACCORDING TO GRADIENT

The table below gives the distance between berms on the more erodible soils such as sand, silt, clay, and disturbed organics. Gravel and undisturbed organic surfaces are not as erodible and do not require berms except on grades of 30 percent or more.

Grade (%)	Distance Between Diversion Berms (m)
5-10	50
10-15	25
15-20	17
20-25	12

If longitudinal grades are steeper than 25 percent on sand, silt, clay, or disturbed organics; or 30 percent on gravel or undisturbed organics; a geotechnical engineer should be consulted for assistance with drainage and erosion control.

USE NATIVE SOIL OR SAND BAGS FOR BERMS

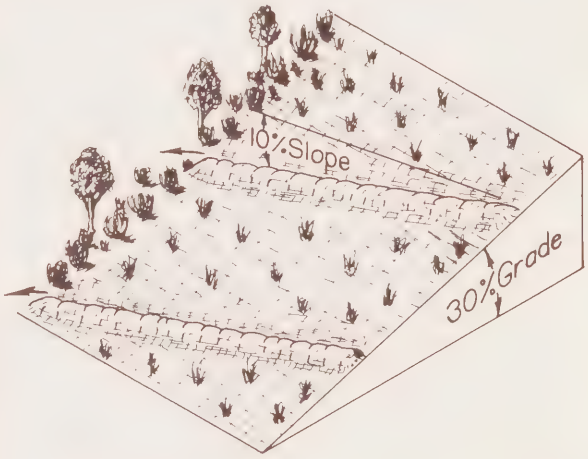
The normal construction procedure for berms in unfrozen soil or ice-poor permafrost is to push up the natural soil surface into a mound. A ditch may be excavated on the upslope side of the berm to help contain the drainage flow. The material from the ditch may be used to construct the berm. Tree trunks can be used to help form the berms but should be well covered with soil.

If ice-rich permafrost is present, sand bags should be used to construct the berm. Jute is the preferred fabric for sand-bag construction because it is more resistant to the sun's ultraviolet rays than are artificial fabrics. Sand bags should be built-up in a staggered configuration to minimize the openings.

- **a berm composed of soil piled into a mound**

- **in areas of permafrost, berms built of sand bags are preferred**

Diversion berms should be oriented such that the gradient **along the berm** is between 5 and 10 percent or the berm itself is inclined at least 60° to the fall line.



- **on grades greater than 15 percent, the gradient along the berm should be between 5 and 10 percent**

- **on grades 15 percent and less, orient the berms at least 60 percent to the fall line**

Drainage Ditches

Drainage ditches are used where a creek or stream has to be re-routed. Ditches should be sized to carry the expected peak volume of water. The size of the natural creek or stream is a good guide.

PROTECT DRAINAGE DITCHES CARRYING CONCENTRATED FLOWS

If the flow in the drainage ditch is expected to be concentrated, either as spring run-off or during summer rains, the ditch must be lined with cobbles and boulders to prevent erosion. Ditches carrying a continuous or highly concentrated flow over fine-grained or sandy soils, both of which are particularly susceptible to erosion, should have a filter cloth placed beneath the cobbles and boulders. Your Land Use Inspector or Resource Management Officer can provide direction in finding information on filter cloth.

Drainage ditches can be excavated in moderately ice-rich and ice-rich permafrost but maintenance problems due to thawing and slumping will occur. The use of a filter cloth overlain by cobbles and boulders will minimize these problems.

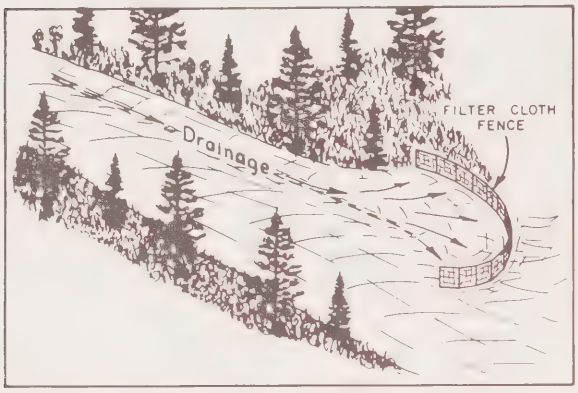
- **this drainage ditch has a filter cloth beneath the cobbles and boulders and a net on top to keep them in place**

INSTALL DITCH BLOCKS TO CONTROL VELOCITIES

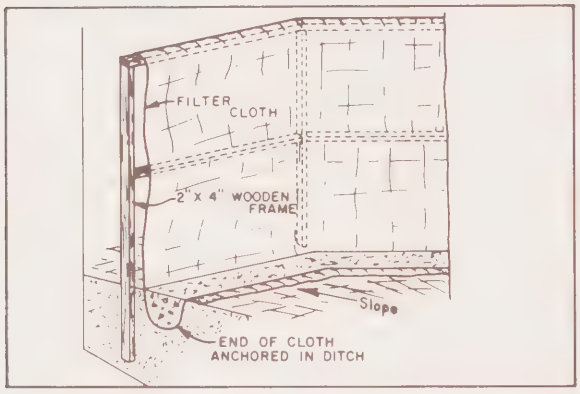
Ditch blocks should be installed at regular intervals to control run-off velocities in the ditch. These are best constructed by piling up boulders. An alternative to boulders is to use jute or woven fabric bags filled with a sand/cement mixture to line the ditch and form ditch blocks. Straw bales may be used as ditch blocks but only for short term and minimal run-off situations.

- **boulders used to reduce flow velocities**

Sediment traps such as a crescent-shaped soil berm or a filter cloth fence will be required for drainage ditches.



- **sediment traps are required at discharge points of drainage ditches**



- **a filter cloth fence is an effective sediment trap**

Erosion Control Blankets

Any erodible soil surface that is steeper than 33 percent grade should have an erosion control blanket placed over the surface. The blanket can greatly reduce the potential for erosion and provide a more stable base for seed germination. Most blankets cost between $1.30 and $2.00 per m^2 (1986 rates) Your seed supplier, Land Use Inspector, or Resource Management Officer can provide direction in finding more information on erosion control blankets.

the placement of an erosion control blanket and application of seed and fertilizer resulted in a marked improvement at this site in only two months

Chapter 5
Revegetation

Revegetation is the process of establishing a protective plant cover on a disturbed surface. It may be accomplished either by encouraging the natural recovery of the local plant communities or through the application of seed and shrub cuttings.

The encouragement of natural recovery may be applicable under either of the following conditions:

(1) The surface disturbance is minimal and over 50 percent of the plants remain rooted.

(2) Water erosion is not expected to be a problem and a rapidly establishing plant cover is not deemed necessary.

Varying degrees of treatment may be used to stimulate natural recovery. In situations where 50 to 75 percent of the plants remain rooted and water erosion is not expected to be a problem, fertilizer alone should be applied to stimulate natural recovery. See Chapter 6 for the recommended application rates for each reclamation region. If more than 75 percent of the plants remain rooted, no treatment is necessary.

Access roads and trails, when abandoned, pose a special case for revegetation. In remote areas it may be possible to leave the road to revegetate without treatment or with scarification only.

DISCUSS TREATMENTS AND NATURAL RECOVERY WITH YOUR LAND USE INSPECTOR

The application of seed and fertilizer to establish a protective plant cover may be applicable under the following conditions:

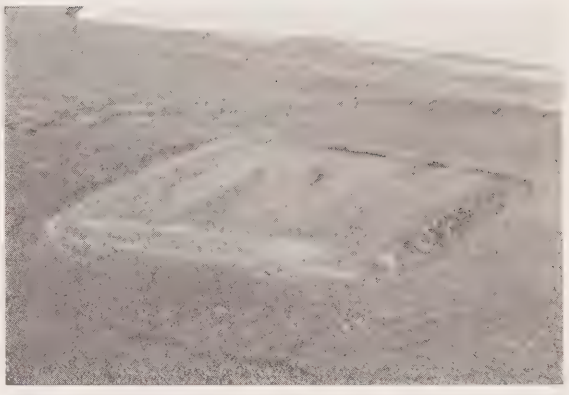
(1) A protective plant cover for erosion control is required sooner than would occur with natural recovery.

(2) A plant cover is required for aesthetic reasons.

(3) It is desirable to slow the invasion of native species, particularly trees and shrubs, in order to reduce maintenance.

This chapter discusses revegetation in terms of surface preparation, soil replacement, and timing and methods of seed and fertilizer application.

PRIOR TO COMMENCING A REVEGETATION PROGRAM, ENSURE THAT DRAINAGE AND EROSION CONTROL STRUCTURES ARE IN PLACE



• **a sump cleaned up and revegetated**

SURFACE PREPARATION AND SOIL REPLACEMENT

Having established final grade and installed drainage and erosion control structures, the surface can be prepared for seeding. Proper surface preparation prior to seeding ensures a much higher seeded species catch. Holes, ruts, and mounds resulting from project activities should be levelled and filled, and upper and lower slope edges should be rounded.

LEVEL SURFACES: ROUND SLOPE EDGES

• **a recontoured mine site, ready for the application of topsoil and seed**

Soil removed and saved during construction should be spread evenly over the surface to a thickness of at least 15 cm. In some cases there will not be enough stripped soil to cover all of the disturbed area. In these instances, soil should be reapplied to sensitive areas such as slopes or, in the case of reclamation for aesthetics, highly visible sites first.

REAPPLY STRIPPED SOIL TO THE MOST SENSITIVE AREAS FIRST

- **re-apply stripped soil following surface preparation**

Compacted roadways and workpads will impede soil drainage and should be ripped to loosen the subsoil. This applies to both exposed surfaces and to those overlain by replaced soil.

Slopes should be scarified perpendicular to their gradient to a minimum depth of 15 cm and maximum spacing of 40 cm.

RIP COMPACTED SURFACES; SCARIFY SLOPES

- **scarification leaves furrows which serve as microsites for seeds to establish**

Smooth surfaces allow seed to wash or blow away. Roughening the surface by scarification or by walking a cat back and forth to create cleat marks provides microsites where seed and moisture will collect. This procedure should be followed on all smooth surfaces that have not already been ripped or scarified as discussed above. Replaced soil generally provides a good seed bed and roughening is normally not required.

ROUGHEN SMOOTH SURFACES TO CREATE SEED MICROSITES

- **cleat marks from a cat provide microsites for seeds to establish**

TIMING OF SEED AND FERTILIZER APPLICATION

The timing of seed and fertilizer application is important to ensure that the seed is not only given the best chance of germinating but also of establishing. If applied too late in the growing season the seeds may germinate but the seedlings will be too immature to survive the winter.

LATE SEEDING DECREASES SURVIVAL RATES

The dates between which seeding can successfully be accomplished are:

Tundra Region:	October 1 to July 1
Woodland Region:	October 1 to July 15
Forest Region:	October 15 to July 30

The first date represents that time of year when seed will not germinate but lie dormant until spring breakup. The second date is the latest that seed can be applied and be expected to establish well enough for seedlings to overwinter.

The best time to seed and fertilize is in spring, immediately following snow melt and runoff when the soil surface is

moist and temperatures are warming. This date varies from region to region but will generally fall between May 1 and June 15.

ROUGHEN THE SNOW SURFACE TO PROVIDE MICRO-SITES FOR SEED

Seeding and fertilizing can also be successfully accomplished in fall and winter while the ground is frozen. In remote areas, winter seeding ensures that some revegetation is accomplished, should it prove difficult or expensive to come back in spring. Best results will be obtained if the disturbance is seeded prior to snowfall but seeding can also be successfully accomplished over the snow. Similar to seeding on soils, revegetation success is improved if the snow surface is roughened to provide microsites for trapping the seed.

• **seeding can be carried out when snow cover is present**

RESEED ERODIBLE SURFACES

Where erosion is a concern, slopes that are winter seeded should receive an additional application of seed and fertilizer in spring or early summer to make up for that which may be lost during runoff.

METHODS OF SEED AND FERTILIZER APPLICATION

Although there are a range of methods available for spreading seed and fertilizer, the cyclone type of spreader is probably the best choice for most northern revegetation operations. These spreaders are mechanically simple and can be hand operated, truck mounted, or slung beneath a helicopter.

• **cyclone seeders can be slung beneath helicopters**

Proper control of width-of-spread and evenness of coverage are important in achieving a uniform vegetation cover. The following are some general guidelines for improving the effectiveness of spreading operations.

CARRY OUT PRACTICE RUNS TO CALIBRATE YOUR SPREADER

(1) Width-of-spread will vary with the density of the material (fertilizer is heavier and spreads further than seed), speed of rotation of the impeller (faster hand cranking throws farther), and height of the spreader above the surface. Prior to the start of revegetation operations it is important to determine the spreading characteristics of your particular combination of equipment and materials and refine your revegetation program accordingly.

(2) The following assumptions on spreading widths can be used for rough planning purposes:

	Spreading width (m)*	
	Seed	Fertilizer
Hand spreader	3-5	5-8
Truck mounted		
low rpm (100-300)	3-5	5-10
high rpm (500-1000)	5-8	10-20
Helicopter slung (bucket at 10-15 m above ground)	10-15	20-25

* Maximum spreading widths are somewhat wider than those shown: however uniformity and rate of application drop off significantly beyond these limits.

(3) Light fluffy seeds such as creeping foxtail tend to impede the flow in the spreader. Buying coated seed or mixing fertilizer with the seed will eliminate this problem. The ratio of seed to fertilizer can be worked out on the basis of specified seed and fertilizer rates so that, if desired, both can be spread in one operation. Mixing of seed and fertilizer should be done just prior to application.

• **mixing seed and fertlizer**

HARROW TO COVER THE SEED

Harrowing to cover the seed with soil will improve seed germination and establishment and is highly recommended. Conventional harrows work best, however dragging brush, heavy chains, or similar materials can provide satisfactory results.

• **using a simple harrow will improve seed germination and establishment**

PLANT SHRUBS TO PROVIDE ADDITIONAL SURFACE PROTECTION

USE OF WOODY PLANTS

Planting shrubs will provide additional subsurface soil strength to that provided by grasses. Roots of shrubs are stronger than roots of grasses and several years after planting they can provide considerable physical support within the surface soil layer. In addition, shrubs can provide a vegetative cover in areas where seeds may be removed by surface erosion.

Shrubs may be used for:

- Subsurface protection on a side hill cut
- Support to diversion berms
- Stream bank protection and habitat improvement

A practical and effective method of establishing shrubs is from stem cuttings taken from shrubs growing near the area to be reclaimed. Willows, generally common throughout the North, are well-adapted to planting as stem cuttings and are discussed in more detail below. Other species such as aspen and balsam poplar can be used, but with reduced success compared to willows.

Soil Conditions

Willows will generally survive in a wide range of soil moisture conditions but will grow best in moist-to-wet, loam-textured soil.

Collection of Cuttings

Willows can generally be located along streams, particularly those with well-developed floodplains. Cuttings can be harvested and planted during spring and early summer.

- **a stand of willow on a floodplain**

LOOK FOR WILLOWS ON FLOODPLAINS

Cuttings should be taken from healthy, vigorous plants growing in full sunlight. Straight stems, 1 to 2 cm in diameter, with smooth bark are most desirable. Cut these stems into 25- to 35-cm sections, discarding the tips of the stems and clipping off all side branches and leaves.

- **these willow cuttings, when established, will increase the stability of this slope**

PLANT CUTTINGS WITHIN 24 HOURS OF HARVESTING

Storage Methods

For best results, harvesting and planting of stem cuttings should occur the same day. However, cuttings can be placed under water for overnight storage with marginal loss of quality.

Planting

Cuttings should be planted in a grid pattern, with the density of planting dependent upon site conditions and erosion risk. Spacing should range from 30 cm on high erosion risk sites to 100 cm on low erosion risk sites. Cuttings should be inserted into the soil at a 30° to 45° angle to a depth of 15 to 25 cm. To prevent stem breakage, a probe or knife can be used to prepare a hole for the cutting. Following planting, tamp the soil firmly around the cutting.

- **willow cuttings have helped stabilize this disturbed slope**

Chapter 6
Seed Mixture and Fertilizer Recommendations

SEED MIXTURE RECOMMENDATIONS

Selection of a suitable seed mixture is determined by the reclamation region in which the project is located and the soil moisture content at the site.

The vegetation region can be determined from the characteristics given in the table on page 8 . Within each region a seed mixture is given for:

(1) Sites with dry-to-moist soils

(2) Sites with moist-to-wet soils, including sites flooded in spring

Seed mixes are provided for Tundra-Woodland and Forest regions only. They are not provided for the Polar Desert region as studies have not shown any commercially available species adapted to this area.

DETERMINE RECLAMATION REGION AND SOIL MOISTURE CONTENT

Sites on slopes will generally be dry to moist. On level ground, soil moisture may range from dry to wet depending on soil texture and permafrost. Gravelly and sandy soils will generally be dry to moist throughout the growing season, while finer-textured soils (silts and clays) will be moist to wet. However, permafrost near the surface can create a perched water table and moist-to-wet conditions in any soil.

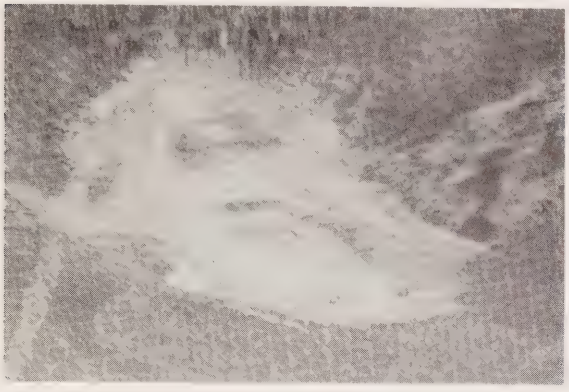
SEED SPECIFICATIONS
TUNDRA – WOODLAND

Species	Variety	% by Weight
Soil Moisture: Moist to Dry		
Creeping red fescue	Arctared	10
Hard fescue	Durar	10
Slender wheatgrass	Revenue	40
Timothy	Engmo	5
Spring rye	Prolific	35
Soil Moisture: Moist to Wet		
Kentucky bluegrass	Nugget	10
Creeping red fescue	Arctared	25
Timothy	Engmo	10
Creeping foxtail	Common or Garrison	20
Spring rye	Prolific	35

SEED SPECIFICATIONS
FOREST

Species	Variety	% by Weight
Site Condition: Moist to Dry		
Creeping red fescue	Boreal	20
Hard fescue	Durar	10
Slender wheatgrass	Revenue	30
Brome grass	Manchar	30
Timothy	Climax	4
Alfalfa	Anik or Drylander	6
Site Condition: Moist to Wet		
Kentucky bluegrass	Common	12
Creeping foxtail	Common or Garrison	35
Reed canarygrass	Vantage	35
Redtop	Common	3
Alsike clover	Aurora	15

For sites where soil chemistry problems may hinder revegetation, such as back-filled drilling mud sumps and mine tailings ponds, a reclamation specialist should be consulted. The Land Use Inspector may provide guidance in this matter.



- **reclamation of this sump, which experienced erosion problems, required assistance from a specialist**

Rate of Seeding

The amount of seed applied per hectare will depend on the erodibility of the site. Erodibility increases with degree of slope. Grades less than 12 percent should receive 30 kg/ha of the seed mixture; grades greater than 12 percent should receive 50 kg/ha.*

INCREASE RATE OF SEEDING ON ERODIBLE SITES.

USE ANNUAL SPECIES FOR RAPID, TEMPORARY EROSION CONTROL

Use of Annuals

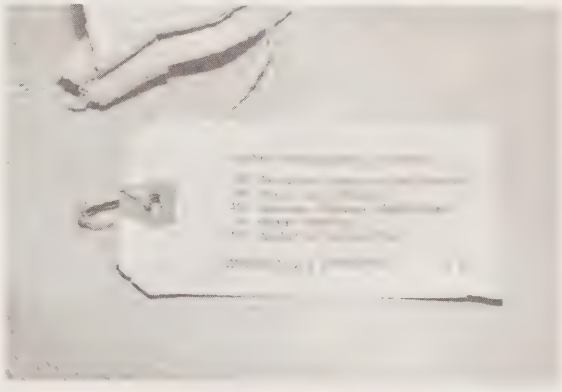
The seeding of annual species such as barley or spring rye alone can be used to provide inexpensive temporary erosion control on areas such as soil storage piles. These annuals establish faster than perennial grasses and can produce a plant cover which lasts one year. Seed should be applied at 30 kg/ha and fertilized as recommended for the particular reclamation region.

USE CANADA NO. 1 CERTIFIED SEED ONLY

Ordering Seed

When ordering seed, identify the variety required and indicate that Canada No. 1 certified seed is wanted. Canada No. 1 seed is guaranteed to have a reasonable germination percentage or viability, and a low level of weed seeds. Certification of the seed ensures that you are getting the variety specified and not another variety which may not be adapted to the area. Seed designated only Canada No. 1 and not certified should be avoided, if possible, as varietal purity cannot be guaranteed.

Seed can be purchased from commercial seed houses. Reliable seed houses will provide a Certificate of Analysis for each species upon request. The certificate of analysis will guarantee varietal purity and specify actual germination as well as content of weeds and other foreign species.

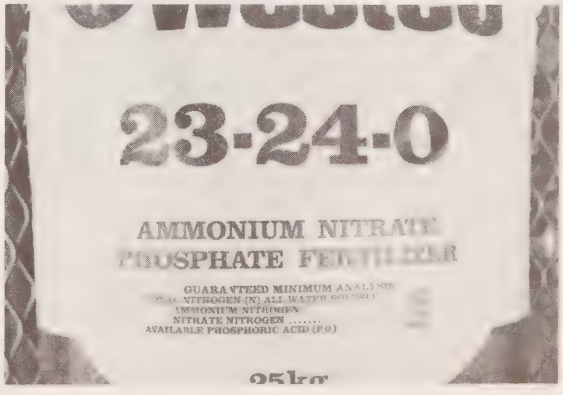


- **use only Canada No. 1 certified seed**

NORTHERN SOILS ARE LOW IN NUTRIENTS AND WILL REQUIRE FERTILIZER

FERTILIZER RECOMMENDATIONS

Fertilizer is required to produce a rapid and complete revegetation cover, especially in northern regions where soils are almost universally low in nutrients. While soil testing is the most precise way of determining fertilizer requirements, numerous studies have established some rules of thumb which are adequate for most soils.



- **this fertilizer contains 23 percent N, 24 percent P_2O_5 and no K_2O**

* See Appendix B for a conversion table showing metric and imperial units for seed and fertilizer application rates.

Suggested fertilizer applications are:

TUNDRA REGION

Nitrogen (N):	50-75 kg/ha
Phosphorus (P_2O_5):	100-150 kg/ha
Potassium (K_2O):	50-75 kg/ha

Apply nutrients in roughly a 1:2:1 ratio.

WOODLAND AND FOREST

Nitrogen (N):	50-100 kg/ha
Phosphorus (P_2O_5):	50 kg/ha
Potassium (K_2O):	50 kg/ha

Apply nutrients in either a 1:1:1 or 2:1:1 ratio.

Doubling the first nutrient, N, will substantially increase plant growth. Where rapid grass cover is desired, doubling the rate of application of any mixture will result in significant increases in first year growth.

- **the application of fertilizer and seed (top photo) results in a better plant cover than occurs with seed alone (bottom photo)**

The fertilizer element rates as specified above are achieved by purchasing an appropriately blended commercial fertilizer. Provided with these specifications, a dealer will help you select the fertilizer blend best suited to your purpose. The following are some guidelines that will help you in the process:

(1) Fertilizers are coded to indicate the percent by weight of each of the three fertilizer elements: N, P_2O_5, and K_2O. For example, a 10-20-10 fertilizer has 10 percent N, 20 percent P_2O_5, and 10 percent K_2O. Therefore 100 kg of this fertilizer will have 10 kg of N, 20 kg of P_2O_5, and 10 kg of K_2O; the remaining 60 kg is inert filler.

(2) For shipping purposes it is important to note that a 10-20-10 fertilizer has the same fertilizer element ratio as a 5-10-5 (i.e. 1-2-1 ratio) one but requires only half the total weight of fertilizer to furnish equivalent amounts of N, P_2O_5, and K_2O; that is, 50 kg of 10-20-10 is equal to 100 kg of 5-10-5.

Your Resource Management Officer can also offer you assistance in determining your fertilizer requirements.

UNDERSTAND FERTILIZER CODES — THEY ARE IMPORTANT IN DETERMINING HOW MUCH IS REQUIRED.

- **the greater the concentration of fertilizer elements, the less the volume required**

Chapter 7
Monitoring

Monitoring of terrain stabilization and revegetation establishment and performance is needed to determine if reclamation objectives were met and, if not, what remedial action is required. It also assists in developing a sound concept of what happens over time following a particular reclamation effort so that, if needed, appropriate changes can be made in future programs.

MONITOR RECLAMATION SUCCESS TO IDENTIFY AREAS REQUIRING REMEDIAL ACTION AND TO IMPROVE FUTURE PROGRAMS

Monitoring may be carried out by either the proponent, to check on reclamation success and initiate remedial action, if necessary, or government officers (Resource Management Officer, Land Use Inspector), to ensure that terms and conditions attached to permits and licences are met.

Reclamation monitoring can take a number of forms depending upon project objectives. In many cases it will require collecting information on plant parameters such as species composition, percentage cover, and vigor, as well as selected observations concerning surface stabilization. This type of information is necessary in evaluating and making adjustments to any reclamation program.

Useful monitoring transects can be established following the general guidelines presented below. These transects are relatively easy to establish and can provide useful information to project or inspection staff as well as yield sound technical data at a later date.

ESTABLISH MONITORING TRANSECTS

(1) Monitoring transects are lines which can be any length but generally range between 5 and 30 m depending upon the size of the disturbance. A metre tape is stretched between the two permanently marked end points and plant/soil observations made adjacent to the line at regular intervals.

- **collecting information along a monitoring transect**

(2) Monitoring transects should be carefully located to be representative of what you are interested in. Information collected from the transect at a later date will accurately define only the transect itself. However if you have selected the transect so that it is similar to or provides an average of the whole area you are interested in, the transect information can be said to be representative of the larger area. Uniformity in such things as moisture conditions, slope, and surface materials are factors which should be looked for in selecting representative sites.

(3) Where a particular disturbance is large, more than one transect should be set up to represent that disturbance. The number of transects needed is a matter of judgement and experience. The accuracy in describing a disturbance will go up as the number of transects increases.

• **stake and tag the start of each monitoring transect for future reference**

• **a second tag, attached to a tree, helps to relocate a transect**

(4) In establishing the transect, it is important that it be tagged and staked with materials that will stand up to the elements. In many cases wooden stakes are adequate, provided they are reasonably sturdy. Where permafrost is near the surface, metal stakes may be necessary. Adjust stake heights in cleared areas so that they are not a hazard to helicopters. The stakes should be painted with a bright color so they can be easily found at a later date and metal tags, coded to indicate site number, affixed to them. An inexpensive engraving pencil can be used to mark most metal tags. If trees are present at the site, a second metal tag attached to a tree is recommended.

(5) Information taken at a site will vary with project objectives but should include:

(a) Type of disturbance

(b) Surface conditions at the time of seeding, type of surface materials (organic or minerals), and an estimate of soil texture

(c) Species and fertilizers used, rate applied, time of application

(d) General topography, slope angle, aspect, and drainage

A rough site sketch is often useful and photographs of the monitoring site are an excellent way of keeping a general record of changes over time. To be most useful they should be taken from the same point each year. In addition to taking photographs along the transect, a general one of the area showing the transect in it should be taken. A 3" x 5" card with the date and site number on it should be placed in the foreground of each picture to facilitate photo identification and comparision at a later date.

Monitoring should be carried out annually until the reclaimed areas have stabilized. This will normally take place over two years but may be longer for highly disturbed areas. Drainage and erosion control measures are best monitored in spring following breakup, while vegetation success is best monitored in summer.

• **photographs and sketches are important parts of data collection at monitoring sites**

Recommended References

Indian and Northern Affairs Canada, 1982. Environmental Guidelines Pits and Quarries.

Indian and Northern Affairs Canada, 1983. Land Use Guidelines Mineral Exploration Yukon and Northwest Territories.

Indian and Northern Affairs Canada, 1984. Land Use Guidelines Access Roads and Trails.

Indian and Northern Affairs Canada, 1986. Environmental Operating Guidelines: Hydrocarbon Well-sites in Northern Canada.

All handbooks are available from INAC offices in Ottawa, Yellowknife, and Whitehorse.

Appendix A
Expressions of a Slope

GRADE (%)	APPROXIMATE ANGLE (°)	APPROXIMATE HORIZONTAL/VERTICAL
5	3	20 to 1
10	6	10 to 1
12	7	8 to 1
15	9	7 to 1
20	11	5 to 1
25	14	4 to 1
30	17	3.3 to 1
33	18	3 to 1
50	27	2 to 1

Appendix B
Seed Mix and Fertilizer Conversion Table

1 kg = 1000 g = 2.2 lbs
1 ha = 10 000 m^2 = 2.47 acre = 107 639 ft^2

50 kg/ha = 5 g/m^2 = 44.5 lb/acre = 1.0 lb/1000 ft^2
30 kg/ha = 3 g/m^2 = 26.7 lb/acre = 0.6 lb/1000 ft^2

Appendix C
List of INAC Offices

NORTHWEST TERRITORIES

Regional Manager, Land Resources
INAC
P.O. Box 1500
Yellowknife, N.W.T.
X1A 2R3

District Superintendent
INAC
P.O. Box 2550
Yellowknife, N.W.T.
X1A 2P8

District Manager
INAC
P.O. Box 658
Fort Smith, N.W.T.
X0E 0P0

District Manager
INAC
P.O. Box 2100
Inuvik, N.W.T.
X0E 0T0

District Manager
INAC
P.O. Box 150
Fort Simpson, N.W.T.
X0E 0N0

District Manager
INAC
Rankin Inlet, N.W.T.
X0C 0G0

Assistant District Manager
INAC
Baker Lake, N.W.T.
X0C 0A0

District Manager
INAC
Iqaluit, N.W.T.
X0A 0H0

Resource Management Officer
INAC
P.O. Box 1420
Hay River, N.W.T.
X0E 0R0

Resource Management Officer
INAC
P.O. Box 126
Norman Wells, N.W.T.
X0E 0V0

Resource Management Officer
INAC
Fort Liard, N.W.T.
X0G 0A0

YUKON TERRITORY

Regional Manager, Land Resources
Attention: Land Use Section
INAC
200 Range Road
Whitehorse, Yukon
Y1A 3V1

Resource Management Officer
INAC
P.O. Box 289
Watson Lake, Yukon
Y0A 1C0

Resource Management Officer
INAC
Teslin, Yukon
Y0A 1B0

Resource Management Officer
INAC
200 Range Road
Whitehorse, Yukon
Y1A 3V1

Resource Management Officer
INAC
P.O. Box 5370
Haines Junction, Yukon
Y0B 1L0

Resource Management Officer
INAC
Beaver Creek, Yukon
Y0B 1A0

Resource Management Officer
INAC
Carmacks, Yukon
Y0B 1C0

Resource Management Officer
INAC
Ross River, Yukon
Y0B 1S0

Resource Management Officer
INAC
P.O. Box 100
Mayo, Yukon
Y0B 1M0

Resource Management Officer
INAC
P.O. Box 279
Dawson City, Yukon
Y0B 1G0

Glossary

Active layer — The top layer of the ground, above the permafrost table, that thaws each summer and refreezes each fall.

Barrens — An area with a lack of vegetation in comparison with adjacent areas.

Bog — An area of confined organic terrain, characterized by a vegetation cover of black spruce, Labrador tea, and peatmoss.

Coarse-textured soils — Soils composed predominantly of gravel, sand, and sandy loam.

Coated seed — Seed that has been covered with a substance to help with either distribution or germination and growth. Creeping foxtail, for example, has light, fluffy seeds which can bunch up in a seed spreader and impede flow. By coating the seed with a thin film of clay, this problem is eliminated. In addition the coating helps with seed establishment by absorbing water and assisting in germination.

Fall line — An imaginery line tracing the path along which water would flow down a slope.

Fen — Organic terrain characterized by a vegetation cover of tamarack, dwarf birch, willow, and moss. Fens are supplied with water previously in contact with mineral soil.

Fine-textured soils — Soils composed predominantly of clay and clay loam.

Habitat — The place where a particular plant or animal or a community of plants or animals naturally lives or grows.

Harrow — The act of covering seed with soil by dragging an implement across the surface.

Heath — A plant community dominated by low growing shrubs, i.e., blueberry, crowberry, cranberry, etc.

Medium-textured soils — Soils composed predominantly of silt loam and silt.

Mineral soil — A soil consisting predominantly of mineral matter. It contains less than 17 percent organic carbon except for an organic surface layer that may be up to 40 cm thick.

Organic soil — A soil developed dominantly from organic deposits. It contains more than 17 percent organic carbon and is at least 40 cm thick.

Scarification — The act of loosening the soil without actually turning it over by dragging a pronged implement across the surface. Scarification, which may be accomplished by using a partially limbed log, increases surface roughness, creating more protection for seed lodging and establishment.

Seed viability — The percentage of seed planted that actually germinates.

Thaw stable permafrost — Permafrost which does not, upon thawing, show loss of strength below normal, long-time thawed values nor produce ground settlement.

Thaw unstable permafrost — Permafrost which shows, on thawing, a significant loss of strength below normal, long-time thawed values and/or significant settlement, as a direct result of melting of the excess ice in the soil.

Tree line — The latitudinal limit or, in mountains, the altitudinal limit, of tree growth.

Tussock — A tufted mound of cottongrass, typically less than 30 cm high, composed of stems and leaves. Tussocks are often umbrella-shaped and usually occur in large tundra meadows.